Bottomland Hardwoods

Bottomland hardwoods (BLH) are basically wet, floodplain forests that are subject to regular seasonal flooding events. Under the USFWS wetlands classification, BLH are in the palustrine system, forested class, and either the broad-leaved or needle-leaved deciduous subclasses (Cowardin et al, 1979). Like all wetland ecosystems, hydrology is the driving factor of a bottomland hardwood. The distribution of bottomland tree species across a site is determined by individual species' tolerance of certain hydrologic regimes (as defined by very small topographical changes in the landscape). Thus, a complete understanding of the hydrology (existing and/or target) is essential for species selection and individual seed/sapling placement across the site.

Due to these considerations, any mitigation project proposed to the Corps (or IRT) with a potential BLH restoration (vegetation and hydrology functional lift) must provide a detailed hydrologic study of the site. This study must have been conducted over a time period of at least one year and will preferably encompass two separate, but successive, flood seasons. Any plans to manipulate or maintain hydrology will be included in the Mitigation Plan.

The relatively slow growth rate of many hardwood trees means that it may take 70-100 years for a mature BLH to fully develop. While some species (cottonwood, sycamore) may reach 30' or more in height in 5 years, others (oak, hickory) may only reach 5'-7' in the same time. In addition, the average age of reproductive maturity of most BLH tree species is 20-25 years. For these reasons it is necessary to monitor the mitigation project for a relatively long period of time to assure trending towards target mature forested system can be verified. However, it is impractical (and impossible) to hold the project until functional maturity, and is probably unnecessary to hold it until reproductive viability. While preferring a minimum of 15 years before release, we recognize the difficulty this time period presents the mitigation provider and have developed a 10-year site work plan schedule. Success is based on reaching specific success criteria and not based on a per annum or time demarcated basis. Thus, the years a project has been in development in no way reflects the level of success of the project.

Note: While reference sites are necessary and will be helpful in setting overall goals for the restoration project, choosing appropriate species for the project should not be based upon reference site conditions, but upon the final target hydrology of the site being

restored . This may not necessarily match historic conditions on the site, but will provide for the highest probability of success. (See **Target Forest Type - TFT**)

Bottomland Hardwood Success Criteria – 10 year

1. Site preparation

- Removal of exotics/invasives, and/or inappropriate or competing species*
- Elimination of impediments to desired hydrology* (removal of roads or berms, filling of ditches, ruts, etc.).
- Establishment/acceptance of Target Forest Type (TFT) (modified from White et al. 1990)

2. Development of hydrology** (continuation of site preparation)

- Construction of final earthworks (establishment of micro-topography)
- Installation of monitoring wells/piezometers/flood gages

3. Tree planting

- Should be initiated after desired hydrology has been attained*, i.e. – after annual flooding regime has been observed (species placement should be based upon micro-topographical and edaphic habitat preference) (Bledsoe & Shear 2000)
- Tree species will be planted to achieve overall target composition of 10-15 species per acre (Clewell pers. comm.) from Table 1, with no greater than 25% coverage of a single species.
- Planted to achieve a coverage of 200-300 stems/acre at 10 years, trending towards 85% canopy coverage, and a basal area of 250-325 ft^2/acre at maturity (Allen et al. 2001)

4. Introduction of shrub and herbaceous layer (if not naturally recruited)

- Should be initiated a minimum of three years after successful establishment of target tree species (Allen et al. 2001), if natural recruitment is not sufficient
- Shrubs must be from Table 2, a minimum of three species, with target cover 20-60%
- Herbaceous layer: ≥ 50% of species present are from Table 3, with appropriate coverage[§] as compared to TFT. If necessary, plantings will be made if colonization has not occurred.

[§] Typical herbaceous coverage in mature BLH may range from 5% (Ezell pers. comm.) to near 100% in situations with high seasonal variability (Allen et al. 2001). Thus, target coverage of herbs needs to be determined according to TFT prior to project initiation and goals to attain this target value need to be established at the time of TFT submittal.

Monitoring:

Monitoring plots must include set fixed plots that are continually monitored to show site succession, and an equal number of randomly placed plots to capture site variability. Random plots must be individually generated for each monitoring event. There shall be a minimum of 1 set and 1 random plot within every 75 acres of contiguous habitat within each polygon. Due to the limited number of required monitoring plots, each plots is required to independently demonstrate achieving required success criteria metrics.

- Hydrology**: well/gage reports, evidence of sediment deposits, drift lines, high water marks.
- Vegetation: target tree, midstory, and groundcover composition, density, and diversity. Positive growth in target tree species trunk diameter and overall height, canopy cover, and basal area.
-Exotics*: <1% cover at all times (no seed bearing plants at any time)

** Hydrologic manipulations and monitoring may not be applicable on all sites. For mitigation banks and ILF projects, the IRT will determine the necessity and feasibility of such endeavors

during the MBI review process, according to the specific site information available for individual sites. If required, both project site and reference wetlands will require hydrologic monitoring.

Bottomland Hardwood Restoration (Vegetation and Hydrology)

Time requirements apply to all projects. Only mitigation banks and ILF projects incorporate the percent credit releases.

20% - Initial release for filing conservation easement/restrictive covenant and providing financial assurance

15% - Upon completion of site preparation and hydrology work (criteria 1 & 2)
- Removal of exotics, invasive, or inappropriate species*
- All earthwork on site completed
- TFT established and accepted
- Monitoring equipment installed**
- Must show that target hydrology has been attained before trees are planted* (minimum 1 year hydrologic monitoring)

15% - Post-planting of trees in **Year 1**
- Target species planted to achieve overall composition of 10-15 species per acre, with no greater than 25% coverage of a single species.
- Minimum of 400 trees per acre, post-planting (White et al 1990)
- Visual and monitored** hydrology show positive correlation with the target hydrology for the site

15% - Post-planting of trees (after 1 year positive growth) approximately **Year 2**
- Visual evidence of target species (and individual seedling) placement in relation to appropriate topographic/hydrologic habitat
- Target trees show positive growth in trunk diameter and overall height.
- Visual and monitored** hydrology show positive correlation with the target hydrology for the site

15% - Post-planting of shrubs and herbaceous layer approximately **Year 4**
- A minimum of three years positive growth of target tree species is required before shrubs and herbs are planted.
- Visual evidence of appropriate shrubs and herbs, planted sparingly or naturally recruited, in small groupings across site (Clewell pers. comm., Allen et al. 2001)
- Visual and monitored** hydrology show positive correlation with the target hydrology for the site

20% - Final credit release (approximately **year 10**).
- A minimum of nine years positive growth of target tree species
- Visual and monitored** hydrology show positive correlation with the target hydrology for the site
- Minimum of 10 target tree species and coverage of 200-300 stems per acre, with all trees showing positive growth in trunk diameter and overall height, with a minimum of 10 trees per acre of each target species (White et al 1990)
- Average height of target canopy a minimum 7'-10' (excluding fast growing species such as *Platanus* and *Populus*)
- 50% of herbaceous species from Table 3, appropriate cover as related to TFT
- 50% of shrub species from Table 2, 20-60% cover
- <1% cover by exotics, no seed producing plants*

Bottomland Hardwood Enhancement (Vegetation Only)

Yearly time requirements apply to all projects. Only mitigation banks and ILF projects incorporate the percent credit releases

20% - Initial release for filing conservation easement/restrictive covenant and providing financial assurance.

10% - Upon completion of site preparation and hydrology verification
- Removal of exotics, invasive, or inappropriate species*
- All earthwork within polygon completed
- TFT established and accepted
- Monitoring plots approved
- Appropriate hydrology verified

10% - Post-planting of trees in **Year 1**
- Target species planted to achieve overall composition of 10-15 species per acre, with no greater than 25% coverage of a single species.
- Minimum of 400 trees per acre, post-planting (White et al 1990)

15% - Post-planting of trees, after 1 year positive growth in **Year 2**
- Visual evidence of target species (and individual seedling) placement in relation to appropriate topographic/hydrologic habitat
- Target trees show positive growth in trunk diameter and overall height

15% - Post-planting of shrubs and herbaceous layer in **Year 4**
- A minimum of three years positive growth of target tree species is required before shrubs and herbs are planted
- Visual evidence of appropriate shrubs and herbs, planted sparingly or naturally recruited, in small groupings across site (Clewell pers. comm., Allen et al. 2001)

10% - Post-planting of all vegetation in **Year 7**
- A minimum of 6 years positive growth of target tree species, with all target trees showing positive growth in trunk diameter and overall height.
- Visual evidence of suitable shrubs with not greater than 60% cover, and herbs with appropriate cover as related to TFT

20% - Final credit release in approximately **Year 10**
- A minimum of nine years positive growth of target tree species
- Minimum of 10 target tree species and coverage of 200-300 stems per acre, with all target trees showing positive growth in trunk diameter and overall height, with a minimum of 10 trees per acre of each target species (White et al 1990)
- Average height of target tree canopy a minimum 7'-10' (excluding fast growing species such as *Platanus* and *Populus*)
- 50% of herbaceous species from Table 3, appropriate cover as related to TFT
- 50% of shrub species from Table 2, a minimum 3 species, with 20-60% cover
- *<1% cover by exotics, no seed producing plants.

Table 1. Appropriate bottomland hardwood tree species (subcanopy and canopy) for restoration work in Mobile District (modified from Clewell 1986).

Acer negundo	*Halesia diptera*	*Populus deltoides*
Acer rubrum	*Hamamelis virginiana*	*Populus heterophylla**
Alnus serrulata	*Ilex cassine*	*Quercus falcata*
*Betula nigra**	*Ilex decidua*	var. *pagodifolia*
*Carpinus caroliniana**	*Ilex opaca*	*Quercus laurifolia*
Carya aquatica	*Juniperus silicola*	*Quercus lyrata*
Celtis laevigata	*Liquidambar styraciflua*	*Quercus nigra*
Chamaecyparis thyoides	*Liriodendron tulipifera*	*Quercus michauxii*
Chionanthus virginicus	*Magnolia virginiana*	*Quercus phellos*
Cornus foemina	*Morus rubra*	*Quercus virginiana*
Crataegus crus-galli	*Nyssa aquatica*	*Salix nigra*
Crataegus marshalli	*Nyssa biflora*	*Symplocos tinctoria*
Crataegus spathulata	*Ostrya virginiana*	*Taxodium ascendens*
Crataegus viridis	*Persea borbonia*	*Taxodium distichum*
Cyrilla racemiflora	*Persea palustris*	*Ulmus alata**
Diospyros virginiana	*Pinus ellottii*	*Ulmus americana*
Fraxinus caroliniana	*Planera aquatica*	*Viburnum dentatum*
Fraxinus pennsylvanica	*Platanus occidentalis*	*Viburnum nudum*

** Species only marginally appropriate, as the Mobile district is at the extreme edge of historical distribution.*

Table 2. Appropriate bottomland hardwood shrub species for restoration work in Mobile District (modified from Clewell 1986).

Alnus serrulata	*Forestiera acuminata*	*Lyonia lucida*
Arundinaria gigantea	*Hypericum galioides*	*Myrica cerifera*
Baccharis glomeruliflora	*Ilex amelanchier*	*Osmanthus americanus*
Callicarpa americana	*Ilex coriacea*	*Sabal palmetto*
Cephalanthus occidentalis	*Ilex glabra*	*Sabal minor*
Cornus amomum	*Illicium floridanum*	*Styrax americana*
Cornus foemina	*Itea virginica*	*Styrax grandifolia**
Crataegus aestivalis	*Leucothoe racemosa*	

** Species only marginally appropriate, as the Mobile district is at the extreme southern edge of historical distribution.*

Table 3. Appropriate herb species for bottomland hardwood restoration work in Mobile District (Allen et al. 2001 - *A Guide to Bottomland Hardwood Restoration*)

Category 1:

Aquatic milkweed	*Asclepias perennis*
Small-spike falsenettle	*Boehmeria cylindrica*
Millet beakrush	*Rhynchospora miliacea*
Water pimpernel	*Samolus valerandi* spp. *parviflorus*
Swamplily	*Crinum americanum*
Bugleweed	*Lycopus* spp.
Lizard's tail	*Saururus cernuus*
Ferns	*Osmunda*, *Woodwardia*, *Thelypteris* spp.

Category 2:

Small-fruit beggartick,	*Bidens mitis*
Mexican water-hemlock	*Cicuta maculata*
Hairlike mock bishop-weed	*Ptilimnium capillacium*
Pickerel weed	*Pontederia cordata*
Smartweed spp.	*Polygonum* spp.
Bur-reed spp.	*Sparganium* spp.

Target Forest Type (TFT) (modified from White et al. 1990)

The Target Forest Type (TFT) includes the selection of an actual reference site (either offsite or potentially onsite outside of the restoration area), but recognizes that bottomland hardwood (BLH) site hydrology and species composition, even among sites within the same watershed, may differ greatly due to edaphic and micro-topographical variations onsite. Thus, the TFT is an amalgam of reference site conditions and suitable species for the particular BLH being restored, created, or enhanced.

The TFT is to be established by the applicant, and is basically a reference site with a supplemental species list. An appropriate reference site needs to be selected in order to establish a target for determining the successful attainment of suitable soils, hydrology, and vegetative cover on the restoration site. However, it should be recognized that species composition and diversity are higher for young forests, and using only the species found on a mature reference site is not appropriate for restoration success. So, as part of the site preparation, a list of the 10-15 tree species that will be planted must be approved to the Corps (IRT for mitigation banks and ILF projects) as a supplement to the selected reference site. The species should be chosen based on the hydrology of the site after all earthwork has been completed, inclusive of reference site species and additional suitable species. Thus, final micro-topography and hydrology can be considered in choosing appropriate species to augment those found on the reference site.

It is the applicant's responsibility to characterize the Target Forest Type (reference site and species list) to the satisfaction of the Corps (IRT for mitigation banks/ILF Projects).

Possible criteria for determining whether or not a site is appropriate for enhancement or restoration. All factors were modified from a study by White et al. 1990. Restoration requires functional lift to hydrology and vegetation, enhancement can involve lift to vegetation only.

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Beck, D.E. "*Liriodendron tulipifera* L. – Yellow-Poplar"
Bey, C.F. "*Ulmus americana* L. – American Elm"
Filer, Jr. T.H. "*Quercus nuttallii* Palmer – Nuttall Oak"
Grelen, H.E. "*Betula nigra* L. – River Birch"
Johnson, R.L. "*Nyssa aquatica* L. – Water Tupelo"
Kennedy, Jr., H.E. "*Fraxinus pennsylvanica* Marsh. – Green Ash"
Kormanik, P.P. "*Liquidambar styraciflua* L. – Sweetgum"
McGee, C.E. "*Nyssa sylvatica* Marsh. – Black Tupelo"
McReynolds, R.D., and E.A. Hebb. "*Quercus laurifolia* Michx. – Laurel Oak"
Pitcher, J.A., and J.S. McKnight. "*Salix nigra* Marsh. – Black Willow"
Rogers, R. "*Quercus alba* L. - White Oak"
Sclaegel, B.E. "*Quercus phellos* L. – Willow Oak"
Smith, H.C. "*Carya cordiformis* (Wangenh.) K. Koch – Bitternut Hickory"
Solomon, J.D. "*Quercus lyrata* Walt. – Overcup Oak"
Vozzo, J.A. "*Quercus nigra* L. – Water Oak"
Walters, R.S., and H.W. Yawney. "*Acer rubrum* L. – Red Maple"
Wells, O.O., and R.C. Schmidtling. "*Platanus occidentalis* L. – Sycamore"
"*Populus deltoides* Bartr. Ex Marsh. – Eastern Cottonwood"
"*Quercus falcata* var. *pagodifolia* Ell. – Cherrybark Oak"

The following articles concerning specific tree species characteristics may be found through the "USDA Forest Service Silvics Manual" at http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1:

Little, S., and P.W. Grant. "*Chamaecyparis thyoides* (L.) B.S. P. – Atlantic White-Cedar"
Wilhite, L.P., and J.R. Toliver. "*Taxodium distichum* (L.) Rich. – Baldcypress"

On-line resources include articles from the ERDC Waterways Experiment Station (WES) at http://www.wes.army.mil/el/workshop/:

Reed, M.R., K.T. Barnett, and K.W. McLeod. "Competition control necessary for bottomland hardwood restoration?"

McLeod, K.W., M.R. Reed, V.H. Parrish, and T.G. Ciravolo. "Bottomland restoration in the Southeastern coastal plain."

And articles from USDA NRCS Wetland Restoration Series at http://www.pwrc.usgs.gov/wli/:

Melvin, N.C. "Vegetation restoration recommendations – bottomland hardwood forests."

Melvin, N.C. "Evaluation of reforestation in the Lower Mississippi River alluvial valley."